AMENDMENTS TO THE CLAIMS

Claim 1 (Previously Presented) A receiving beam-forming method comprising:

arranging 'n' ultrasonic transducer elements into a predetermined form;

dividing the ultrasonic transducer elements into multiple blocks, where 'p' ultrasonic transducer elements are illuminated by an acoustic signal, where 'p' ≤ 'n';

repeatedly sampling signals received by 'p' ultrasonic transducer elements at a specific scanning frequency;

forming sample data for the blocks for a scanning cycle, where a scanning cycle is dependent on a wavelength of the acoustic signal;

selecting sample data; and

forming the receiving beams using the selected sample data.

Claim 2 (Previously Presented) The receiving beam-forming method according to claim 26, wherein the signals received by the 'p' ultrasonic transducer elements are pulse signals whose pulselength is shorter than the extent of the 'n' ultrasonic transducer elements arranged in the predetermined form as measured along the direction of a receiving beam.

Claim 3 (Previously Presented) The receiving beam-forming method

according to claim 26, wherein the acoustic signal is composed of growing waves whose amplitude gradually increases or damped waves whose amplitude gradually decreases.

Claim 4 (Previously Presented) The receiving beam-forming method of claim 26, wherein the arc is obtained by selecting an arc-shaped part of a cylindrical form, wherein the receiving beam-forming direction is rotated by switching the selection of the arc-shaped part of the cylindrical form.

Claim 5 (Cancelled)

Claim 6 (Previously Presented) The receiving beam-forming method according to claim 27, wherein the acoustic signal is composed of pulse signals whose pulselength is shorter than the extent of the 'n' ultrasonic transducer elements as measured along the direction of a receiving beam.

Claim 7 (Previously Presented) The receiving beam-forming method according to claim 27, wherein the acoustic signal is composed of growing waves whose amplitude gradually increases or damped waves whose amplitude gradually decreases.

Claim 8 (Previously Presented) The receiving beam-forming method

according to claim 27, wherein selection of the scanning cycles for the individual blocks is altered according to the angle between the direction of the receiving beam and the ultrasonic transducer elements arranged in the linear form.

Claim 9 (Previously Presented) A receiving beam-forming method comprising:

arranging 'n' ultrasonic transducer elements into a predetermined form;

dividing the plurality of ultrasonic transducer elements into multiple blocks, where 'p' ultrasonic transducer elements are illuminated by an acoustic signal, where 'p' ≤ 'n';

repeatedly sampling signals received by 'p' ultrasonic transducer elements at a specific scanning frequency;

forming sample data for the blocks for a scanning cycle, where a scanning cycle is dependent on the scanning frequency;

storing said sample data; and

forming a receiving beam in a specific direction using selected sample data.

Claim 10 (Previously Presented) A receiving beam-forming apparatus comprising:

a multiplexer which multiplexes echo signals received by multiple ultrasonic transducer elements arranged in a predetermined

form on a receiving transducer, where the echo signals are multiplexed into a number of signal lines, where the number of signal lines is less than the number of the ultrasonic transducer elements;

an A/D converter which repeatedly samples the echo signals received by the individual ultrasonic transducer elements at a specific scanning frequency and outputs complex-valued sample data; and

a signal processor which divides the multiple ultrasonic transducer elements into multiple blocks, selects the sample data derived from different scanning cycles for the blocks, where a scanning cycle is dependent on the scanning frequency, and forms the receiving beams using the selected complex-valued sample data.

Claim 11 (Previously Presented) The receiving beam-forming apparatus of claim 10, wherein the predetermined form is an arc, wherein the arc is obtained by selecting an arc-shaped part of a cylindrical form, wherein a receiving beam-forming direction is rotated by switching the selection of the arc-shaped part of the cylindrical form, wherein a receiving beam-forming direction is rotated by switching the selection of the arc-shaped part of the cylindrical form.

Claim 12 (Withdrawn) A matched filter which selects an arc-shaped

part of ultrasonic transducer elements from a plurality of ultrasonic transducer elements arranged in a circular form and forms a receiving beam oriented in a central direction of said arc-shaped part, said matched filter comprising:

a shift register which has as many stages as a number given by (the number of said ultrasonic transducer elements arranged in the circular form) x (n-1) + (the number of said ultrasonic transducer elements of the arc-shaped part) and stores signal trains obtained from said ultrasonic transducer elements of the arc-shaped part among signal trains of multiple scanning cycles sequentially entered from said ultrasonic transducer elements arranged in the circular form in the order of a signal train of the nth scanning cycle, a signal train of the (n-1)th scanning cycle,...., a signal train of the second scanning cycle and a signal train of the first scanning cycle;

a plurality of multipliers which divide said ultrasonic transducer elements of the arc-shaped part into n blocks according to the direction in which the receiving beam is formed, selects signals of the ultrasonic transducer elements of a block closest to the beam direction from the signal train of the nth scanning cycle, selects signals of the ultrasonic transducer elements of a block next to the block closest to the beam direction from the signal train of the (n-1)th scanning cycle,....., selects signals of the ultrasonic transducer elements of a block next to a block most

distant from the beam direction from the signal train of the second scanning cycle, selects signals of the ultrasonic transducer elements of the block most distant from the beam direction from the signal train of the first scanning cycle, and multiplies the individual signals by corresponding coefficients; and

an adder which adds up results of multiplications performed by the individual multipliers and outputs the sum as correlation data.

Claim 13 (Withdrawn) A matched filter which selects an arc-shaped part of ultrasonic transducer elements from multiple ultrasonic transducer elements arranged in a partially cutaway circular form and forms a receiving beam oriented in a central direction of said arc-shaped part,

wherein n number of shift registers having as many stages as the number of said multiple ultrasonic transducer elements arranged in the partially cutaway circular form and shift registers having as many stages as the number of said ultrasonic transducer elements of the arc-shaped part are connected in parallel, and said matched filter stores signal trains obtained from said ultrasonic transducer elements of the arc-shaped part among signal trains of multiple scanning cycles sequentially entered from said ultrasonic transducer elements arranged in the partially cutaway circular form in the order of a signal train of the nth scanning cycle, a signal train of the (n-1)th scanning cycle,....., a signal train of the

second scanning cycle and a signal train of the first scanning cycle while loading them in parallel between the individual shift registers, said matched filter comprising:

a plurality of multipliers which divide said ultrasonic transducer elements of the arc-shaped part into n blocks according to the direction in which the receiving beam is formed, selects signals of the ultrasonic transducer elements of a block closest to the beam direction from the signal train of the nth scanning cycle, selects signals of the ultrasonic transducer elements of a block next to the block closest to the beam direction from the signal train of the (n-1)th scanning cycle,....., selects signals of the ultrasonic transducer elements of a block next to a block most distant from the beam direction from the signal train of the second scanning cycle, selects signals of the ultrasonic transducer elements of the block most distant from the beam direction from the signal train of the first scanning cycle, and multiplies the individual signals by corresponding coefficients; and

an adder which adds up results of multiplications performed by the individual multipliers and outputs the sum as correlation data.

Claim 14 (Withdrawn) The matched filter according to claim 12 or 13, wherein the signal trans entered from said multiple ultrasonic transducer elements are complex-valued sample data trains, and wherein said matched filter comprises:

two lines of said shift registers for in-phase data and quadrature data;

four lines of said multipliers and said adder for in-phase data x in-phase coefficient, quadrature data x quadrature coefficient, in-phase data x quadrature coefficient, and quadrature data x in-phase coefficient; and

an output section which determines an in-phase portion of a correlation value by subtracting the product of in-phase data x in-phase coefficient from the product of quadrature data x quadrature coefficient, and determines a quadrature portion of the correlation value by adding the product of in-phase data x quadrature coefficient and the product of quadrature data x in-phase coefficient.

Claim 15 (Withdrawn) The matched filter according to claim 12, 13 or 14, wherein multiple sets of the coefficients are provided such that the receiving beam can be focused at varying distances.

Claim 16 (Withdrawn) A receiving beam-forming apparatus in which echo signals received by multiple ultrasonic transducer elements arranged in a linear form are sampled at a specific scanning frequency to obtain sample data, said receiving beam-forming apparatus comprising:

a memory which stores the sample data derived from multiple

scanning cycles; and

a beamformer which divides the multiple ultrasonic transducer elements into multiple blocks, reads out the sample data derived from different scanning cycles for the individual blocks from said memory, and forms a receiving beam in a specific direction using the individual sample data which have been read out.

Claim 17 (Withdrawn) The receiving beam-forming apparatus according to claim 16, wherein selection of the scanning cycles for the individual blocks is altered according to the angle between the direction of the receiving beam and the ultrasonic transducer elements arranged in the linear form.

Claim 18 (Withdrawn) The receiving beam-forming apparatus according to claim 16 or 17, wherein said beamformer is a matched filter which forms the receiving beam in the specific direction by multiplying the individual sample data by specific coefficients, and said matched filter is provided with multiple sets of the coefficients so that the receiving beam can be focused at varying distances.

Claim 19 (Previously Presented) A receiving beam-forming apparatus comprising:

a plurality of ultrasonic transducer elements arranged on a

predetermined form;

a plurality of ultrasonic transducer elements receiving echo signals, where the transducer elements are sampled at a specific scanning frequency, forming sample data for a scanning cycle, where a scanning cycle is dependent on the scanning frequency;

a memory which stores the sample data from multiple scanning cycles; and

a beamformer which forms a receiving beam in a specific direction using the sample data.

Claim 20 (Currently Amended) A receiving beam-forming apparatus which repeatedly samples echo signals received by multiple ultrasonic transducer elements at a specific scanning frequency and forms a receiving beam using sample data obtained by sampling the echo signals in multiple scanning cycles, where a scanning cycle is dependent on the scanning frequency<u>, and wherein said sampling being performed, in accordance with a scanning cycle, at a rate higher than the scanning frequency</u>.

Claim 21 (Withdrawn) A sonar system which emits an ultrasonic search pulse signal and receives echo signals by receiving beams formed successively and oriented in successively varying directions, said sonar system comprising:

a plurality of transducer elements for receiving echo signals

of a specific frequency;

a plurality of A/D converters which convert analog signals supplied from said transducer elements into digital form;

means for generating in-phase data of complex-valued sample data and quadrature data of complex-valued sample data from the digital signals; and

a matched filter for receiving the in-phase data of complex-valued sample data and quadrature data of complex-valued sample data from said generating means and successively forming the receiving beams in different directions.

Claim 22 (Withdrawn) The sonar system as claimed in claim 21 wherein the matched filter comprises a first memory unit for storing complex valued sample data resulting from echo signals, a second memory unit for storing complex coefficients, a plurality of multipliers for multiplying the sample data with the corresponding complex coefficients respectively, and adder for adding the output signals from the multipliers, and an amplitude detector for producing based on the output signals of the adder output signals forming a reception beam.

Claim 23 (Withdrawn) The sonar system as claimed in the claim 21 wherein the plurality of transducer elements are arranged on the surface of a sphere at space intervals.

Claim 24 (Withdrawn) A sonar system which emits an ultrasonic search pulse signal and receives echo signals by receiving beams formed successively and oriented in successively varying directions, said sonar system comprising:

a plurality of groups of transducer elements for receiving echo signals of a specific frequency;

a plurality of multiplexers which multiplex signals entered successively from each of said groups of the transducer elements into a smaller number of channels than the number of said transducer elements, wherein said multiplexers operate with synchronized switching timing;

a plurality of A/D converters which convert analog signals entered respectively and individually from said multiplexers into digital form, wherein said A/D converters operate with synchronized sampling timing;

means for generating in-phase data of complex-valued sample data and quadrature data of complex-valued sample data from the digital signals; and

a matched filter for receiving the in-phase data of complex-valued sample data from said generating means and successively forming the receiving beams in different directions,

the matched filter comprising a first memory unit for storing complex valued sample data resulting from echo signals, a second memory unit for storing complex coefficients, a plurality of

multipliers for multiplying the sample data with the corresponding complex coefficients respectively, an adder for adding the output signals from the multipliers, and an amplitude detector for producing based on the output signals of the adder output signals forming a reception beam.

Claim 25 (Withdrawn) The sonar system as claimed in the claim 24 wherein the plurality of the transducer elements are arranged on the surface of a sphere at space intervals.

Claim 26 (Previously Presented) The method of claim 9 further comprising the step of producing a continuous sample data train by shifting the phase of the sample data for the blocks;

Claim 27 (Previously Presented) The apparatus of claim 19 further comprising a sampling plane generator, which produces a continuous sample data train of a sampling plane corresponding to a specific angle, where the specific angle is obtained by shifting the phase of or interpolating the sample data from the multiple scanning cycles

Claim 28 (Previously Presented) The method of claim 1, wherein the predetermined form is an arc.

Claim 29 (Previously Presented) The method of claim 1, wherein the predetermined form is linear.

Claim 30 (Previously Presented) The method of claim 9, wherein the predetermined form is an arc.

Claim 31 (Previously Presented) The method of claim 9, wherein the predetermined form is linear.

Claim 32 (Previously Presented) The apparatus according to claim 10, wherein the predetermined form is an arc.

Claim 33 (Previously Presented) The apparatus according to claim 10, wherein the predetermined form is linear.

Claim 34 (Currently Amended) A receiving beam-forming apparatus, comprising:

a plurality of transducer elements that repeatedly sample echo signals received at a specific scanning frequency; and

a signal processor to form a receiving beam using sample data obtained by sampling the echo signals in multiple scanning cycles, wherein a scanning cycle is dependent on the scanning frequency, and wherein said sampling being performed, in accordance with a scanning cycle, at a rate higher than the scanning frequency.